WHITE PAPER NO. 21 – GREEN BAY MODELING

EVALUATION OF A HYPOTHETICAL OPEN-WATER DISPOSAL SITE FOR NAVIGATIONAL DREDGED MATERIAL IN SOUTHERN GREEN BAY

Response to Comments on the

REMEDIAL INVESTIGATION FOR THE

LOWER FOX RIVER AND GREEN BAY, WISCONSIN,

FEASIBILITY STUDY FOR THE LOWER FOX RIVER AND GREEN BAY, WISCONSIN,

PROPOSED REMEDIAL ACTION PLAN FOR THE

LOWER FOX RIVER AND GREEN BAY, AND

RECORD OF DECISION FOR OPERABLE UNIT 1 AND OPERABLE UNIT 2

This Document has been Prepared by

HydroQual, Inc.

for the

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ABSTRACT

This white paper was prepared in response to comments raised during the public comment period for the *Final Remedial Investigation for the Lower Fox River and Green Bay, Wisconsin* (RI) (RETEC, 2002a), the *Final Feasibility Study for the Lower Fox River and Green Bay, Wisconsin* (FS) (RETEC, 2002b) and the *Proposed Remedial Action Plan, Lower Fox River and Green Bay* (Proposed Plan) (WDNR and EPA, 2001). Commenters expressed concern that sediments dredged to maintain navigational channels in the past were disposed of either as side-cast to the navigation channels, or were placed in open-water disposal areas in southern Green Bay. Since those areas had not been previously sampled for polychlorinated biphenyls (PCBs), there was the potential to encounter high concentrations, and that those areas continued to serve as a PCB reservoir, contaminating other parts of the Bay.

To address this concern, hypothetical modeling scenarios were constructed that assumed that PCB concentrations within a dredged material disposal site area at both 10 parts per million (ppm) (micrograms per gram [µg/g] solid) and 1 ppm, respectively, with 1 ppm representing the post-remediation scenario. GBTOXe was run to determine how Bay-wide surface sediment concentrations might change over time with and without remedial action in the River for the hypothetical dredged material disposal site.

Using the GBTOXe fate and transport model, the results of this evaluation indicate that the sediment located at dredged material disposal sites redistribute to other zones. The results from analysis of long-term PCB mass transfer indicated that 71 percent of the PCB mass would be redistributed from the deposit site to other locations, and that the resultant sediment concentrations would not be significantly different after 10 years.

1 INTRODUCTION

In a post evaluation of the Remedial Investigation/Feasibility Study (RI/FS) modeling efforts of PCB fate and transport in Green Bay, interest was raised over the possibility that open-water disposal of sediments dredged to maintain navigational channels of southern Green Bay may cause elevated sediment PCB concentrations at the locations that receive the dredged material. To address this issue, the Green Bay PCB fate and transport model, GBTOXe, was used to evaluate the Bay-wide effects of a hypothetical dredged material disposal site in southern Green Bay. The model was used to compare a no remedial action scenario and post-action scenario. The Wisconsin Department of Natural Resources (WDNR) specified the no action and post-action PCB concentrations within the dredged material disposal site area to be 10 ppm (µg/g solid) and 1 ppm, respectively. The Lower Fox River loading was specified to correspond to the 1 ppm remedial action level scenario of the RI/FS. Two 100-year GBTOXe simulations were performed to show how Bay-wide surface sediment concentrations change over time with and without remedial action at the hypothetical dredged material disposal site.

2 METHODS

The site selected by WDNR for this hypothetical analysis is a dredged material disposal site located east of the navigational channel that extends to the shore of Green Bay by Point Au Sable as shown on Figure 1. In terms of the GBTOXe model grid, this location is approximated as the surface and subsurface sediment cells that underlie water column cell 48, which is within the Zone 2 region. The gray area of Figure 2 presents the location of this grid cell within model domain. The affected surface area is 12 square kilometers (3 percent of the total surface area of Zone 2), and represents the sediment area to which the no action and post-action initial condition concentrations were applied.

PCB load and initial conditions for both simulations were based on the RI/FS 100-year simulation with Green Bay and the Lower Fox River remedial action levels of no action and 1,000 parts per billion (ppb), respectively. The model grid cell numbers that represent the sediment layers underlying water column cell 48 are 1538, 1687, and 1836, and have depth intervals of 0 to 2, 2 to 4, and 4 to 10 centimeters (cm), respectively. The initial conditions for PCBs in these cells were modified in the GBTOXe input files based on a bulk density of 0.5 grams per cubic centimeter (g/cm^3) and a PCB concentration of 10 ppm (µg/g dry weight) for the no action case or 1 ppm for the post-action case, in accordance with specifications provided by WDNR. The PCB initial condition for the bottom sediment cell (1985, 10 to 31 cm) was not modified. Given a no action initial concentration of 10 ppm to a depth of 10 cm and a bulk density of 0.5 g/cm^3, the no action PCB mass in the dredged material disposal site sediment volume corresponds to 6,000 kilograms (kg). Assuming a 1 ppm remedial action level, the remaining PCB mass corresponds to 600 kg.

To evaluate the Bay-wide effects on sediment and water column PCBs in response to the no action and post-action scenarios, the complete 100-year time series of sediment and water column PCB model results from both simulations (spatially averaged across each GBFood zone and on an organic carbon-normalized basis) were compared.

3 RESULTS

Annual average PCB concentrations were computed from the results of the no action and post-action 100-year simulations. The top three panels of Figures 3 through 6 present comparisons of the time series of the annually averaged carbon-normalized PCB concentrations in sediment layers 0 to 2, 2 to 4, and 4 to 10 cm for each GBFood region. The bottom panels of Figures 3 through 6 represent the time series of concentrations vertically averaged over the upper 10 cm of sediment, weighted by interval depth. These figures show that the most substantial differences between the no action and post-action carbon-normalized sediment PCB concentrations occur in Zone 2 (Figure 3). Annual average PCB concentrations computed in Zone 2 in the first year of the post-action simulation are 43 percent lower than the results of the no action simulation. However, sediment PCB concentrations computed in the no action simulation decrease rapidly and tend to approach the post-action concentrations towards the end of the first 10 years at all depth intervals. After 10 years, the difference between the Zone 2 results computed in the two simulations continues to decrease, but at a slower rate than in the first 10 years. Differences between the results of the two simulations, averaged over the upper 10 cm (bottom panel of Figure 3) decrease from 15 percent at year 10 to 9.4 percent at year 100. Table 1 summarizes the comparison of the 0- to 10-cm sediment PCB concentrations at specific time intervals.

For the other GBFood regions (i.e., Zone 3A, Zone 3B, and Zone 4), a comparison of the no action and post-action sediment PCB concentrations shows that the 1 ppm remedial action level at the hypothetical dredged material disposal site has a relatively small effect. PCB concentrations computed in Zone 3A (Figure 4) and Zone 3B (Figure 5) in the remedial action simulation are only slightly different from the no action results throughout the simulation period. In Zone 4 (Figure 6), the results from the two simulations are very similar, with differences of near or less than 1 percent.

Figure 7 presents a comparison of the annually averaged water column dissolved PCB concentrations from the no action and post-action simulations for each GBFood zone. The Bay-wide impact on water column dissolved PCB concentrations computed in response to remedial action at the hypothetical dredged material disposal site is most clearly evident in Zone 2 during the first 10 years. This would be expected since the greatest redistribution of Zone 2 sediment PCBs occurs during this period. Post-action water column PCB concentrations in zones 3A, 3B, and 4 are only slightly lower than results from the no action simulation and tend to approach the no action concentrations after year 10. Zone 2 water column PCB concentrations computed in the first year of the post-action simulation are 27 percent lower than concentrations computed in the no action simulation. Zone 2 water column dissolved PCB concentrations computed in both simulations decrease from over 4 nanograms per liter (ng/L) at year 10 to less than 1 ng/L at year 100. During this time period, Zone 2 dissolved PCB concentrations computed in the post-action simulation are approximately 10 percent lower than concentrations computed in the no action simulation. Table 2 summarizes the comparison of concentrations in the water column at specific time intervals.

In general, GBTOXe model results indicate that Bay-wide reductions in sediment and water column PCB concentrations, in response to a 1 ppm remedial action level at the hypothetical dredged material disposal site, are greatest in Zone 2 but tend to become less appreciable after the first 10 years of the simulation period. By contrast, model results indicate that there is no appreciable impact to sediment and water column PCB concentrations for zones 3A, 3B, and 4. The relatively rapid decline of PCB concentrations within the first 10 cm of sediment, which is computed in the no action simulation, is due, in part, to the computed transfer of PCBs to the bottom sediment layer. This computed flux is affected by the large concentration gradient between the bottom and upper sediment layers specified in the initial conditions for the simulation. As the gradient is reduced, the computed burial flux between sediment layers becomes less of a factor. Over the long term, an analysis of the PCB mass transfer indicates that 71 percent of the PCB mass from the hypothetical dredged material disposal site sediments is eventually redistributed to other zones after 25 years.

4 REFERENCES

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TABLE 1 NO ACTION AND POST-ACTION SEDIMENT PCB CONCENTRATIONS (µG/G OC) (AVERAGED OVER 0 TO 10 CM)

Year	Zone 2			Zone 3A			Zone 3B			Zone 4		
	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.
1	55.1	31.6	42.7	9.68	9.63	0.5	8.00	7.95	0.6	4.88	4.88	0.0
10	38.5	32.8	14.7	9.46	8.90	5.9	3.34	3.14	6.0	5.06	5.03	0.6
25	35.5	31.5	11.4	9.03	8.51	5.8	2.32	2.18	6.0	5.13	5.09	0.8
50	23.7	21.1	11.1	8.15	7.68	5.8	1.56	1.46	6.4	5.13	5.07	1.2
75	15.9	14.3	10.5	7.01	6.61	5.7	1.01	0.94	6.9	5.03	4.98	1.0
100	10.9	9.9	9.4	5.96	5.64	5.4	0.67	0.63	6.0	4.92	4.88	0.8

TABLE 2 NO ACTION AND POST-ACTION DISSOLVED PCB CONCENTRATIONS IN WATER COLUMN

Year	Zone 2			Zone 3A			Zone 3B			Zone 4		
	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.	No Action	Post-Action	% Diff.
1	6.98	5.07	27.4	2.37	2.04	14	2.42	2.13	12	0.61	0.59	3.3
10	4.76	4.28	10.1	1.49	1.34	10	1.38	1.24	10	0.51	0.48	5.9
25	4.13	3.81	7.75	1.17	1.07	8.6	1.04	0.95	8.7	0.52	0.40	4.8
50	2.39	2.18	8.79	0.78	0.71	9	0.68	0.62	8.8	0.34	0.33	3.0
75	1.33	1.20	9.77	0.53	0.49	7.6	0.45	0.41	8.9	0.29	0.28	3.5
100	0.87	0.80	8.1	0.39	0.36	7.7	0.32	0.30	6.3	0.25	0.25	0

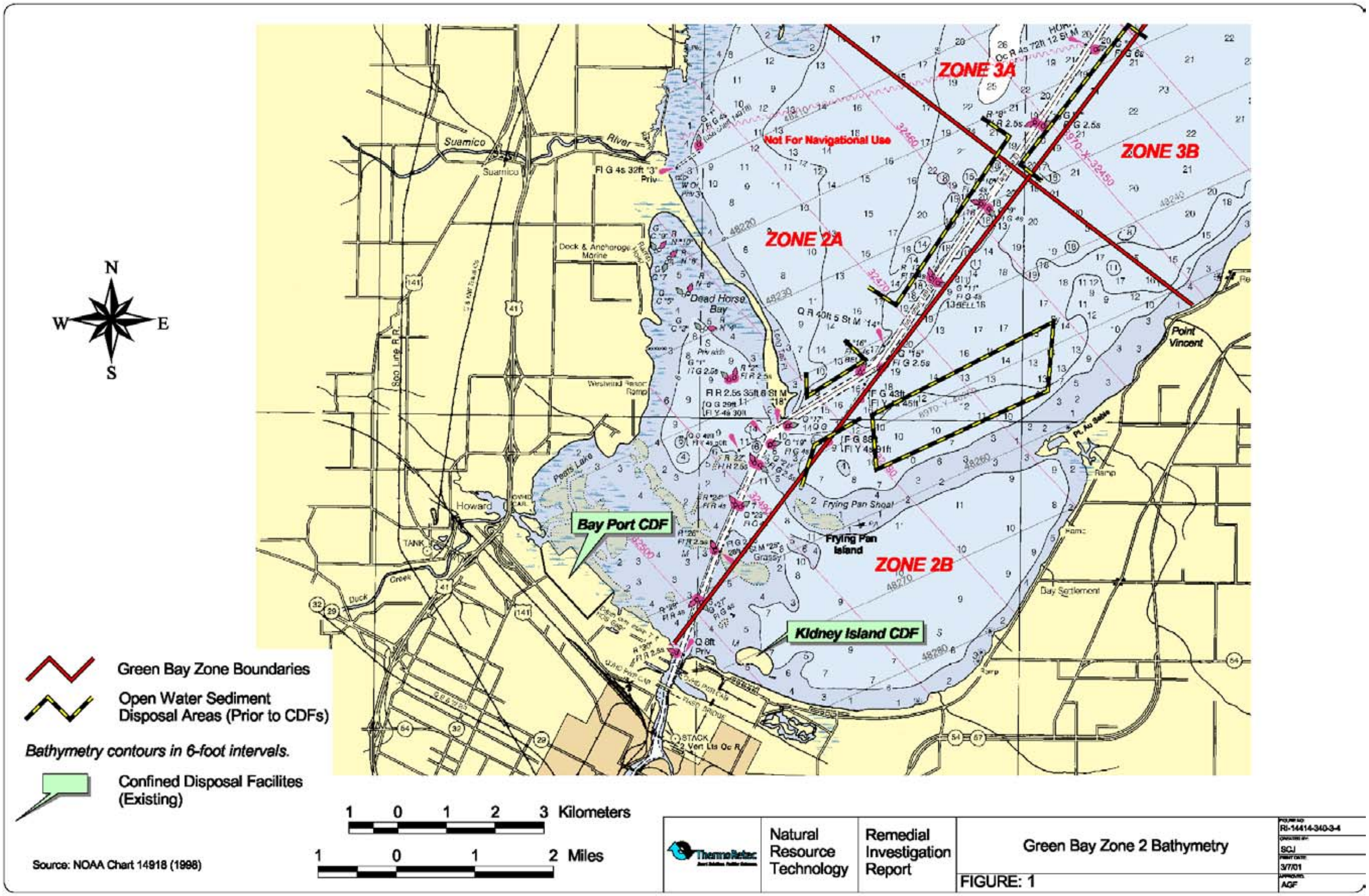
ZONE 3A
ZONE 3B
ZONE 2A
ZONE 2B
Not For Navigational Use
Bay Port CDF
Kidney Island CDF
Frying Pan Shoal
Frying Pan Island
Dead Horse Bay
Point Vincent
Pt. Au Sable
Suamico
Suamico River
Howard
Duck Creek
Peats Lake
Dock & Anchorage Marine
Day Settlement
N
E
S
W
Green Bay Zone Boundaries
Open Water Sediment Disposal Areas (Prior to CDFs)
Bathymetry contours in 6-foot intervals.
Confined Disposal Facilites (Existing)
1 0 1 2 3 Kilometers
1 0 1 2 Miles
Source: NOAA Chart 14918 (1998)
ThermoRetec
Natural Resource Technology
Remedial Investigation Report
Green Bay Zone 2 Bathymetry
FIGURE: 1
RI-14414-340-3-4
SCJ
3/7/01
AGF

FIGURE 2 GBTOXe SURFACE AREA CORRESPONDING TO DREDGE MATERIAL DISPOSAL SITE

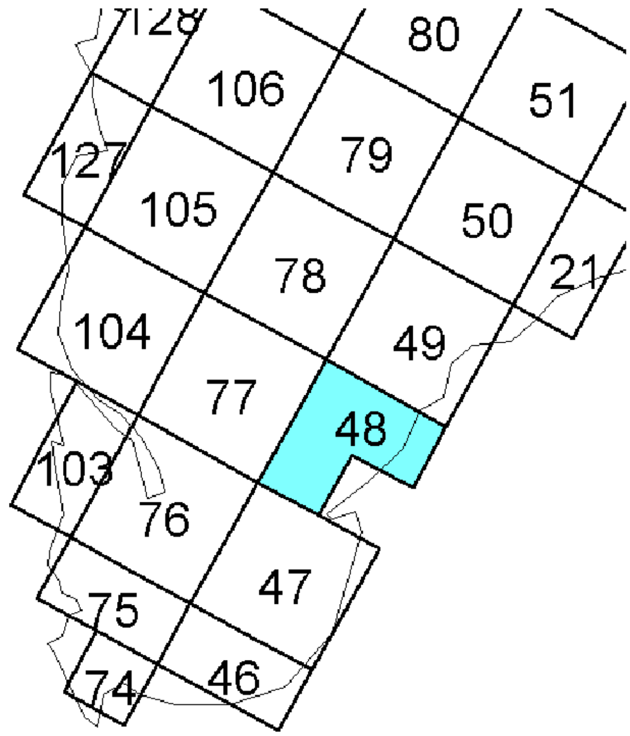

FIGURE 3 ZONE 2 PCB SEDIMENT RESPONSE TO NO-ACTION AND POST-ACTION AT DREDGE MATERIAL DISPOSAL SITE

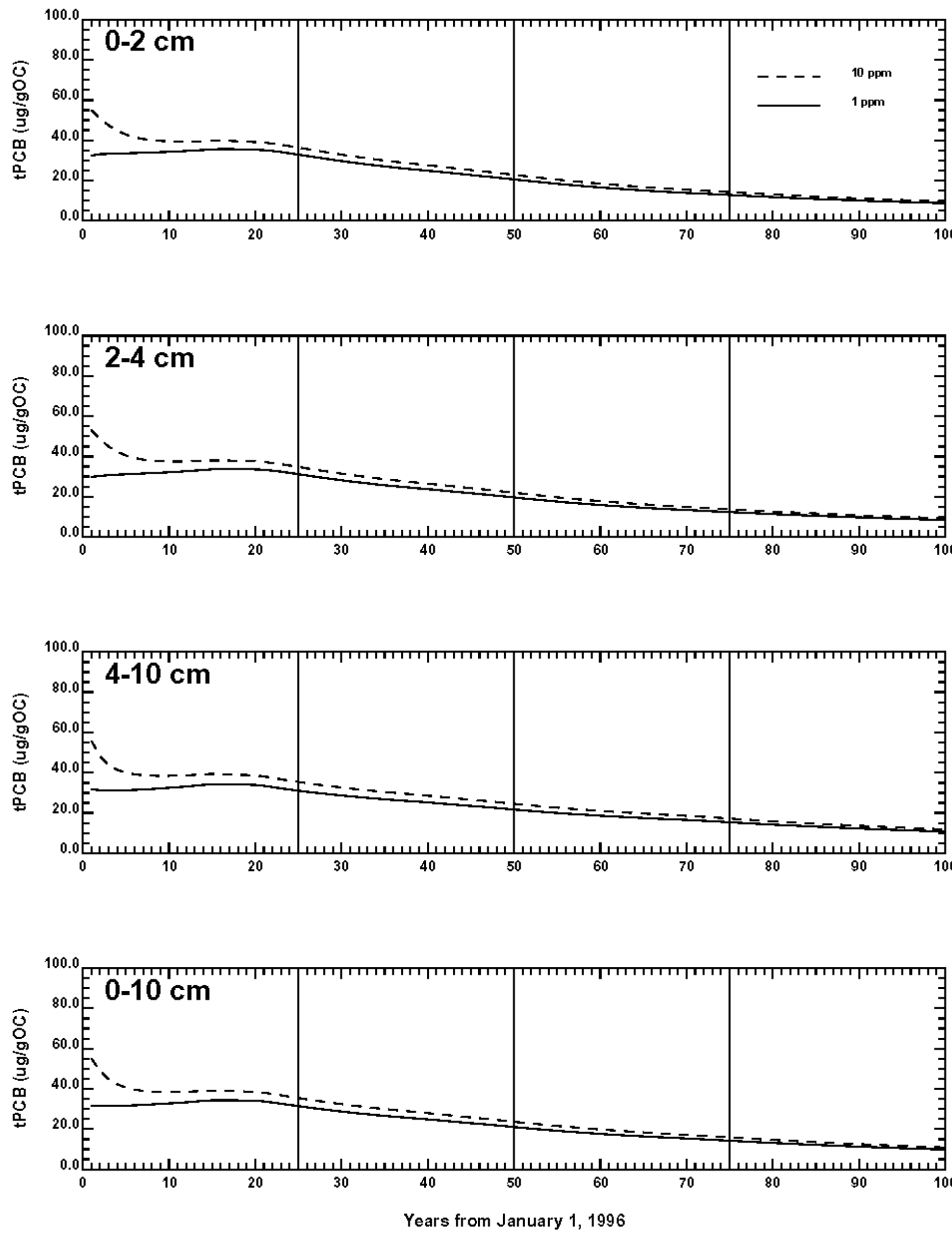

FIGURE 4 ZONE 3A PCB SEDIMENT RESPONSE TO NO-ACTION AND POST-ACTION AT DREDGE MATERIAL DISPOSAL SITE

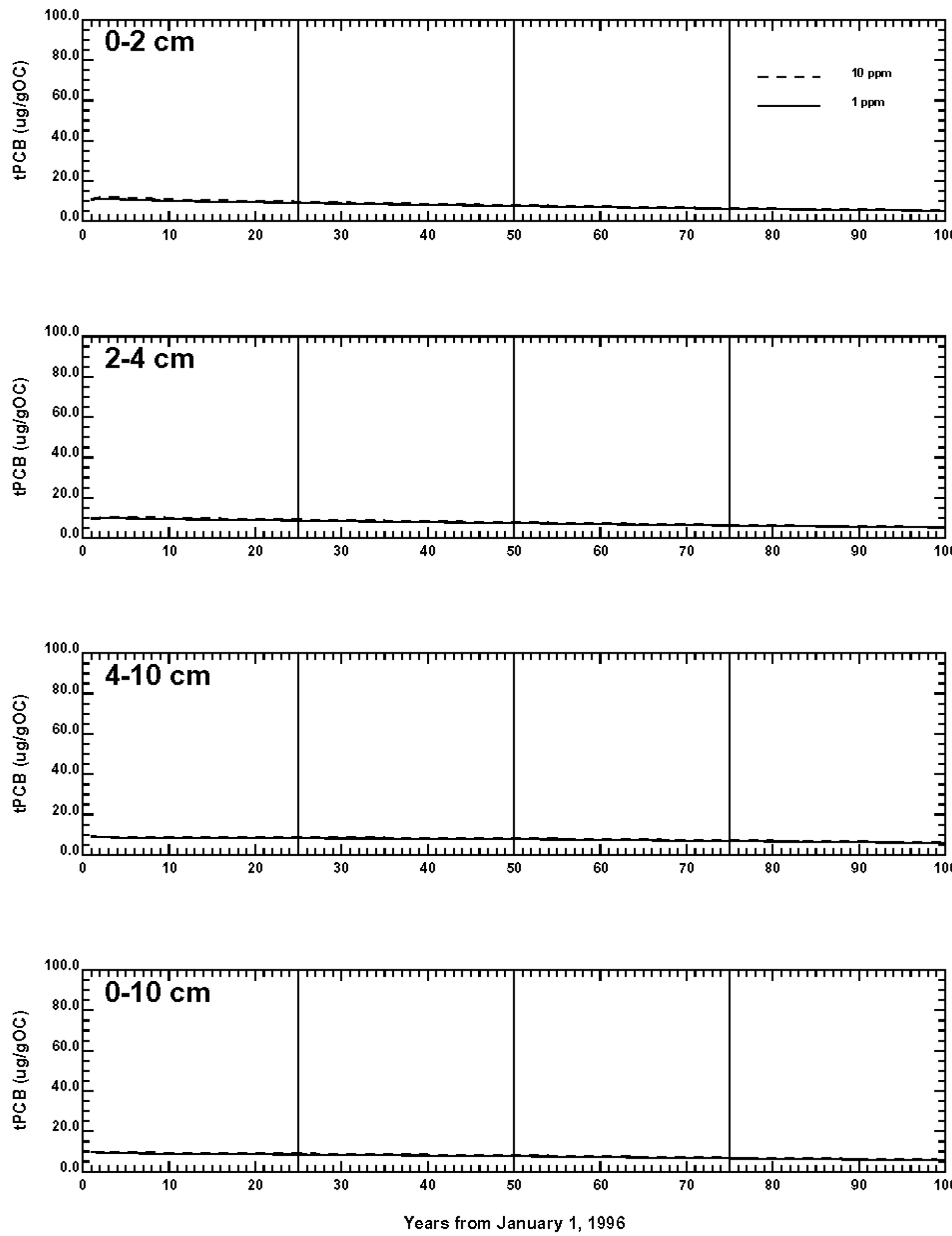

FIGURE 5 ZONE 3B PCB SEDIMENT RESPONSE TO NO-ACTION AND POST-ACTION AT DREDGE MATERIAL DISPOSAL SITE

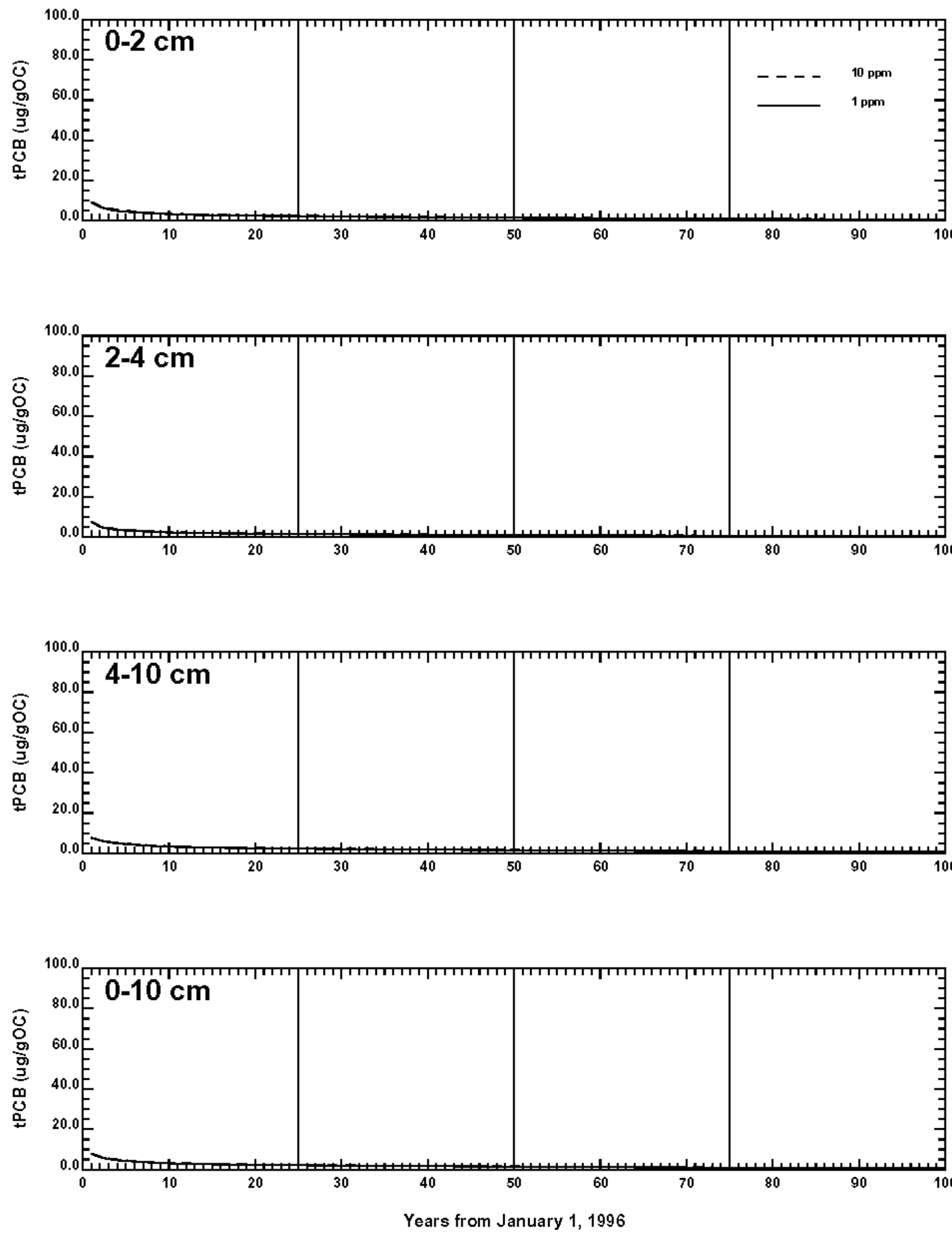

FIGURE 6 ZONE 4 PCB SEDIMENT RESPONSE TO NO-ACTION AND POST-ACTION AT DREDGE MATERIAL DISPOSAL SITE

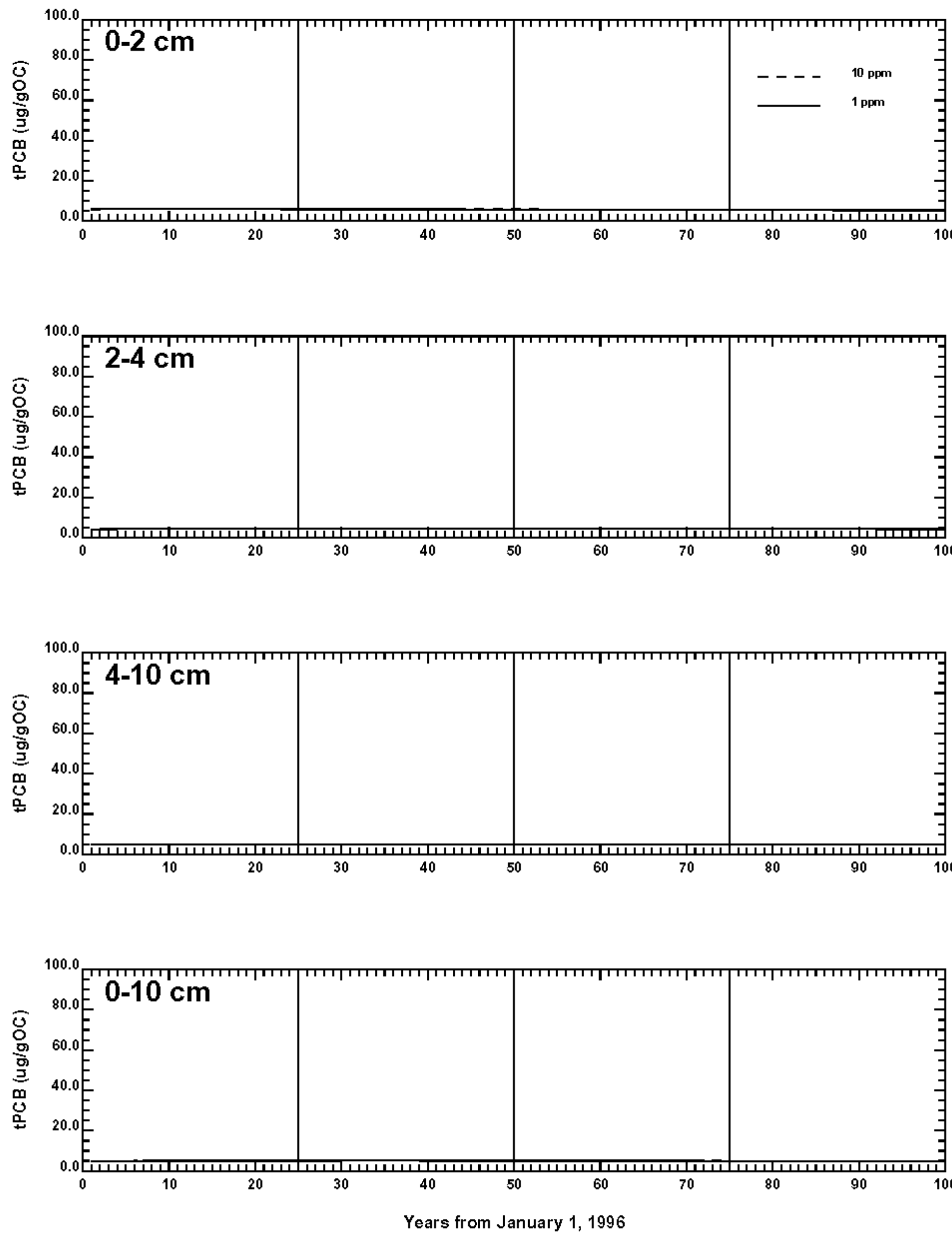

FIGURE 7 WATER COLUMN PCB RESPONSE TO NO-ACTION AND POST-ACTION AT DREDGE MATERIAL DISPOSAL SITE